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PROGRAMED TUTORING--A TEACHING AID AND A RESEARCH TOOL.

BY- ELLSON, D.G. AND OTHERS

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TEN EXPERIMENTS ON THE DEVELOPMENT AND TESTING OF THE PROGRAMED TUTORING TECHNIQUE AND ITS APPLICATION TO THE TEACHING OF BEGINNING READING ARE SUMMARIZED. THE BEHAVIOR OF PROFESSIONALLY UNTRAINED PERSONS IN THIS TECHNIQUE WAS PROGRAMED IN AGREEMENT WITH PRINCIPLES OF LEARNING AND PROGRAMED INSTRUCTION FOR INDIVIDUAL TEACHING. FOUR HUNDRED CHILDREN, INCLUDING RETARDED CHILDREN, SLOW READERS, AND UNSELECTED POPULATIONS OF CHILDREN IN KINDERGARTEN AND FIRST GRADE, WERE TUTORED FOR PERIODS RANGING UP TO NINE SEMESTERS. WITH A FEW EXCEPTIONS, INCLUDING ONE "NORMAL" FIRST GRADER AND SEVERAL CHILDREN WITH IQ'S BELOW 50, NO TUTORED CHILD FAILED TO READ. PROGRAMED TUTORING WAS FOUND TO BE MOST SUCCESSFUL WHEN USED AS A SUPPLEMENT TO AND COORDINATED WITH REGULAR CLASSROOM TEACHING. WHEN USED THIS WAY, IT PRODUCED SIGNIFICANT IMPROVEMENT ON STANDARD TESTS WHICH REQUIRED SIGHT-READING, COMPREHENSION, AND WORD ANALYSIS. TABLES, FIGURES, APPENDIXES, AND REFERENCES ARE INCLUDED. THIS ARTICLE IS PUBLISHED IN "READING RESEARCH QUARTERLY," VOLUME 1, NUMBER 1, FALL, 1965. (MD)

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Programed tutoring:

a teaching aid and a research tool

ED010760

D. G. ELLSON, LARRY BARBER,
T. L. ENGLE, and LEONARD KAMPWERTH
Indiana University

THIS IS A summary report of ten experiments in which the technique of programed tutoring, applied to the teaching of beginning reading, is developed and given preliminary field tests.

The behavior of professionally untrained persons in this technique is programed in agreement with principles of learning and programed instruction for individual teaching.

A total of 400 children were tutored in the experiments. They included retarded children, slow readers, and unselected populations of children in kindergarten and first grade, for periods up to one semester. With the exception of one "normal" first-grader and some, but not all, of a small group of children with IQ's below 50, no tutored children failed to read.

The data of several experiments indicated that programed tutoring is most successful when used as a supplement to and coordinated with regular classroom teaching. Used in this way, it produced significant improvement on standard tests which required sight-reading, comprehension, and word analysis.

Enseignment programmée

CECI EST UN rapport résumé de dix expériences au cours desquelles la technique d'enseignment programmée, appliquée à la méthode de donner les leçons de lire est developpée et soumise à des essais préliminaires.

La conduite des personnes sans entraînement professionel

This research was carried out with the support of U.S. Public Health Service Grants M-4786 (A), MH 04989, and HD00694 and the cooperation of the For Wayne State Hospital and Training School and the public schools of New Haven, Fort Wayne, Bloomington, and Indianapolis, Indiana.
Mr. Barber took special responsibility in carrying out Experiments I, II, VI and later experiments; Dr. Engle for III and VII; and Mr. Kampwerth for IV and V. A major contribution to the development of Word Analysis programs was made by Mrs. Renie Adams. We are greatly indebted to P[illegible] Fay for backstopping advice in the broad field of reading instruct[illegible]

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dans cette technique est programmée en accord avec les principes d'apprendre et avec l'instruction programmée pour l'enseignement individuel. Un total de 400 enfants ont été entraîné dans cette expérience.

Dans ce nombre étaient des enfants retardés, ceux qui lisent lentement, et une population non-selectée d'enfants des écoles maternalles et de première année pour des périodes allant jusqu'à un semestre.

Avec l'exception d'un enfant de première année qui était "normal" et d'une fraction d'un petit groupe d'enfants ayant un I.Q. endessous de 50 tous ceux qui avaient été entraînés ont appris à lire. Les données de plusieurs expériences indiquent que l'instruction programmée a le plus de succès quand elle est employée en supplément et en coordination avec l'enseignement régulier. Le programme d'enseignment employé de cette manière améliore d'une manière significative de lire à vue, la compréhension, et l'analyse des mots.

Enseñanza programada con preceptor

ESTE ES un resumen de diez experimentos, en los cuales, la técnica de enseñanza programada con preceptor aplicada al iniciar la enseñanza de la lectura, es desarrollada y comprobada en pruebas prácticas preliminares.

El entrenamiento de personas no preparadas profesionalmente, se planea de acuerdo con principios didácticos e instrucción programada para la enseñanza individual.

En los experimentos se enseñó a un total de 400 niños. Ellos incluyeron niños retardados, lectores lentos y alumnos de kindergarten (jardín de párvulos) y primer grado, no seleccionados, por un período de hasta un semestre. Con la excepción de un niño "normal" de primer grado y algunos, no todos, de un pequeño grupo de niños con cuociente intelectual inferior a 50, todos los niños que recibieron instrucción, aprenderon a leer.

Los informes de varios experimentos indican que la enseñanza programada con preceptor, tiene más éxito cuando se utiliza como complemento y coordinado con la enseñanza en las aulas. El empleo de esta forma dio resultados significativamente mejores en pruebas comunes, que requieren lectura visual, comprensión y análisis de palabras.

> **The goal of education should be nothing short of the fullest possible development of the human organism. An experimental analysis of behavior, carried out under the advantageous conditions of the laboratory, will contribute to progress toward the goal. So will practical experiments conducted in schools and colleges with the help of adequate instrumentation. (B. F. Skinner, 1961, p. 398)**

This paper reports a series of more or less practical experiments, conducted mostly in schools, which have been directed toward two goals: the development of a technique that can contribute to the teaching of elementary reading and the development of an adequate instrument for research in this field. This paper is properly considered a progress report since the project is not complete; in a sense, it is just beginning. It summarizes the results of ten experiments carried out in a state school for retarded children, in many classrooms of public school systems in Indiana, and in associated laboratory settings. Except for a brief summary of the first five (Ellson, 1962), these experiments have not been published and it is believed that several of them are not publishable separately. Some are experiments only in the primitive sense of tryouts; in others, a carefully planned design was abandoned in midstream to permit informal investigation of obviously important effects that had not been anticipated in the planning. Such a research strategy, coupled with the relative chaos that characterizes the smoothest-running elementary classrooms in an effective working school, does not always lead to the kind of report that a journal will publish, especially if it is written honestly. But this strategy was appropriate to the aims of the research and to the present state of the art. When ground is first broken in any field of research the effects of some variables are so obvious that subtle statistical tests, control groups, or, in some cases, even experiments are not necessary for their detection.

The seemingly casual strategy can also be justified by the results of some of the later experiments to be summarized below. The technique that has developed seems to be a highly effective device for teaching beginning reading, at least when used as a supplement to traditional classroom methods. But, possibly more important, it turns out to be a relatively precise and sensitive research instrument that greatly expands the possibility of well-controlled experimentation within the complex and fluid activity of the normal classroom.

One important aspect of the developmental-research activity will largely be omitted in this paper: namely, the use of basic scientific theory, the many applications of the available systematized knowl-

edge of learning and related processes. Throughout, it was extremely useful, if not absolutely necessary, to describe every observation and translate every description of reading and the teaching of reading that was encountered into the technical language of objective psychology. The key words in this language are *stimulus* (situation), *response* (behavior), and *reinforcement* (reward, approval, feedback, information). Unresolved problems are associated with the last of these terms. A *theory of reinforcement* capable of specifying the necessary and sufficient conditions for the occurrence of reinforcement is not yet available. However, *reinforcement theory*, which predicts the effects of reinforcement—pragmatically defined—under a variety of conditions, has been developed to the point of useful applicability.

To formulate job analyses of reading and the teaching of reading in these technical terms is to build a semantic bridge that brings the problems of the classroom and the knowledge of the learning laboratory much closer than they presently seem. Translated in this way, not only specific problems faced by teachers but many general aims of teaching become, if not identical to, at least recognizable as questions that have been asked and sometimes answered in the laboratory. Because of the complexity of the teaching situation and practical limitations on what can be done in a working school, not all of these answers can be applied, nor are they necessarily successful when applied. However, it can be affirmed that they are extremely useful in planning teaching strategies in schema and detail, and in suggesting solutions to the continual stream of concrete problems that arise when one attempts to teach on a realistic scale. This semantic device for establishing communication between the laboratory and the field is no doubt more easily applied and perhaps more effective in programed tutoring than it can be for the classroom teacher.

In what follows, the procedures and some of the formal results of ten experiments are summarized. An attempt is made to outline the findings derived (with varying degrees of certainty) from this research. Finally, the technique of programed tutoring that has evolved to date on the basis of experimental results and more subtle information of which there is no explicit physical or psychological record is described.

Reading is a complex activity that, as a minimum, includes oral or sight-reading, phonics, and comprehension. Among these, oral reading reasonably comes first both in a teaching and a research program because of its relative psychological simplicity. Phonic analysis

and synthesis is clearly not necessary at the start, and the comprehension of the meanings of visually presented words or of the sentences in which they occur cannot precede their identification. The latter is most easily indicated by an oral response. For these and other reasons, the investigation began with the teaching of oral reading of single words. The first limited goal was the automation of sight-reading vocabulary drill for retarded children. It was hoped that some very dedicated teachers would be relieved of a deadly, unrewarding chore.

Automation of the teaching of oral reading poses one technical problem that is not critical in most other work with programed instruction and teaching machines. Although machines can provide most of the basic conditions necessary to produce learning, they do not listen well; they cannot distinguish (and thus differentially reinforce) correct and incorrect oral responses with the proficiency required for teaching purposes. Consequently, it was necessary to utilize at least one human component in conjunction with the teaching machine to make this discrimination. As a matter of convenience, this necessary person was also given more extensive responsibilities, so that he was properly called a *tutor*. His behavior was otherwise fully determined by the programs so that he was appropriately called a programed *tutor* and our technique, *programed tutoring*.

EXPERIMENT I

Acquisition of sight-reading vocabulary by retarded children using pictures as prompt-stimuli

Subjects were 38 retardates, residents of the Fort Wayne State School, mean CA 16, range 11 to 40; mean IQ 54, range 25–74, distributed randomly to experimental and control groups. Apparatus consisted of a wooden screen, with an opening in which a word or a word and a picture could be exposed, which separated experimenter and subject. Lights for reinforcement were mounted at the top. The learning material was chosen from a list of 82 words selected from the 1500-word reading vocabulary for the primary grades prepared by Gates (1935) in which each word was paired with a picture which the children named with that word only. A 150-word general reading vocabulary test was constructed by selecting every tenth word from the same Gates list arranged in order of frequency, with words in the learning

material excluded. This test was administered twice to both groups and the program presented below was used.

The Picture Program summarized below and the Sight-reading Program presented later are branched rather than linear. Since single branches are repeated with successive units of material, they are appropriately called cycled branch programs. They differ from most programs [1] in that they do not include special organization of a body of subject matter, but are recursive teaching procedures adapted to sequences of material in units defined primarily by form, e.g., words and sentences.

The picture program

Presentation of the program was preceded by an introductory statement describing the procedure in simple words and emphasizing that a brief flash of the lights at the top of the screen indicated that the child had read the word correctly.

Step 1: The tutor shows a word. If the learner's oral response is correct, the tutor reinforces (by flashing a light) and proceeds to the next word, Step 1. If incorrect, the tutor proceeds to Step 2.

Step 2: The tutor shows the same word and a corresponding picture. If the learner's oral response is correct, the tutor proceeds to Step 3. If incorrect, the tutor names the picture (word) correctly and the learner repeats. The tutor then proceeds to Step 3.

Step 3: The tutor removes the picture, leaving the word visible, and the learner is asked to repeat it once more. If the oral response is correct, the tutor reinforces and proceeds to the next word, Step 1. If incorrect, the tutor names the word correctly and the learner repeats. The tutor then proceeds to the next word, Step 1.

Following an appropriate introduction, this program was applied successively to all words in the learning material on Trials 1 and 5. On Trials 2, 3, and 4, it was followed only for words *not known*, i.e., not correctly read in Step 1 on any previous trial. Trial 6, similar to Trials 1 and 5, was given one month after Trial 5 as a retention test.

The mean number of words read correctly by the experimental group on Step 1 in Trials 1, 5, and 6 are shown in Table 1.

1. See, for example, Lumsdaine and Glaser (1960) and Hansen, Christman, and Seidel (1963).

Table 1 Learning and retention, experimental group

	Means
Trial 1	20.9
Trial 5	32.7
Gain	11.8*
Trial 6	27.7
Loss	5.0 (43%)

* $p < .01$

Table 2 Vocabulary test (Not practiced during learning trials)

	Experimental group	*Control group*
Pre-test	17.0	17.9
Post-test	24.1	20.9
Gain	7.1	2.8
p_{gain}	<.05	<.20

Note.—The difference in gain for the two groups was significant at the <.20 level.

The mean total time required for the five learning trials was 36.7 minutes, giving a mean learning rate over this short period of approximately 19 words per hour. Retention after one month was not remarkable.

Pre- and post-test scores on the general reading vocabulary test for experimental and control groups are shown in Table 2.

The results for the experimental group are interesting in that they show significant improvement in a performance not practiced, which might be described as a "therapeutic" effect. They also suggest that some of the "learning" shown in Table 1 may have been relearning or latent learning (all of the subjects had some prior school background). These suggestions were followed up in later investigations.

EXPERIMENT II

The use of retarded tutors

Experiment II was an informal test of the feasibility of using retarded children as tutors. Two residents of the State School were taught without difficulty to administer the Picture Program used in Experiment I. Less than two hours was required for training in each case. These tutors were characterized as follows: Tutor A: CA, 14; IQ, 71. Tutor B: CA, 17; IQ, 58.

Tutor A taught one retarded child seven words; Tutor B taught four retarded children a mean of 28 words. The average rate of acquisition (23 words per hour) was slightly higher than that attained in Experiment I in which the tutor was a college graduate.

Whether or not the results obtained in Experiments I and II represent true initial learning or the reinstatement of prior learning, they indicate that the paired associates procedure in the Picture Pro-

gram form is a feasible technique for increasing the reading vocabulary of retarded children. However, except for special purposes, this program has been abandoned. It will be noted that the pictures were used as stimuli, not as illustrations; as stimuli, they are effective only if the response to them is uniform. The picture of a robin, for example, cannot be used since it evokes at least two verbal responses with non-negligible frequency, e.g., "bird" and "robin". Less than 20 per cent of the words in the Gates list of 1500 most frequent words can be pictured with sufficient nonambiguity for this technique, and these are not the most useful in a sight-reading vocabulary. There is also some evidence (teachers' opinions) that the use of pictures in teaching these words increases the difficulty of teaching more important words which cannot be pictured adequately.

EXPERIMENT III

Test of a sight-reading program using verbal prompts

A sight-reading program which taught words in a sentence context was developed and given a preliminary test with three groups of children. For this and several experiments that followed, the reading material for the program was printed in primary type on a scroll and presented by a "teaching machine" designed to expose either one sentence alone or one sentence and the words of that sentence in random order. The program, preceded by appropriate instructions, was applied to consecutive sentences in a story designed for adult beginning readers.

Sight-reading program, utilizing oral prompts

Step 1: The machine shows the sentence. If the sentence is read correctly orally, the tutor reinforces and proceeds to the next sentence, Step 1. If the sentence is not read or is read incorrectly (error in reading any word) the tutor proceeds to Step 2.

Step 2: The machine shows the sentence and, below this, the words of the sentence in a random order *A*. The tutor reads the sentence, then points to the words below one at a time in the given random order. If all words are read correctly, the tutor reinforces each word as it is read and proceeds to Step 3. If any word is read incorrectly, the tutor reads it to the child, who repeats it, and then proceeds to the next word. After the last word, the tutor proceeds to Step 3.

Step 3: The machine shows the sentence. If the child reads the sentence correctly, the tutor reinforces and proceeds to the next sentence, Step 1. If the sentence is not read, or any word is read incorrectly, the tutor proceeds to Step 4.

Step 4: The machine shows the sentence. The tutor reads the sentence, then, leaving it visible, names the words of that sentence, one at a time, in a random order *B* (different from that in Step 2), the learner pointing as the tutor reads. If all words are pointed to correctly, the tutor reinforces and proceeds to Step 5. If any word is not indicated correctly, the tutor points correctly and the learner then points. After the last word the tutor proceeds to Step 5.

Step 5: The machine shows the sentence. If the sentence is read correctly, the tutor reinforces and proceeds to the next sentence, Step 1. If there is error in any word, the tutor reads the word orally and the learner repeats. After the last word the tutor proceeds to the next sentence, Step 1.

Sessions began either with the first sentence in the learning material or, after progress had been made, with the third sentence preceding the first on which an error had been made in the preceding session. Eight half-hour sessions were given, two per week for four weeks. At the beginning of each session, on a ninth test session, and on the retention test session one month later, a reading recall test was administered in which all of the 57 words in the learning material, printed in columns in primary type, were presented. Data in Table 3 and Figure 1 are based on these tests.

Three groups of four subjects each, *a*] normal first-grade children, *b*] slow readers in the first grade, and *c*] retardates similar to those in Experiment 1, were taught under the conditions described above. All of the retarded children had had previous schooling but were considered to be non-readers by the staff of the school in which they were residents. Subject characteristics for the experimental groups, gains during the learning, and retention over the following month are summarized in Table 3. Mean rates of learning were ap-

Table 3 CA, IQ, words learned, and one month retention

Group	*Mean CA*	*Mean IQ*	*Mean gain*	*Mean % retention*
Normal	6–4	108	30.5	94
Slow	7–1	93	20.0	92
Retarded	18–1	54	19.5	90

proximately five new words per hour for the retarded and slow groups and 7.5 for the normals.

In comparable control groups given only the initial and final tests, mean gains for the normal, slow, and retarded groups respectively were 7.5, 2.6, and −0.2 words. Retention was not computed for the control groups because of loss of subjects due to vacation schedules.

The initial rates of increase in vocabulary for all experimental groups were similar (Figure 1A), but individual curves for the normals showed relatively constant rates overall or positive acceleration (Figure 1B), while most of those for the retarded children and slow readers (Figures 1C and 1D) showed decreasing rates. This negative acceleration raised questions concerning the effectiveness of the technique for teaching those children who have difficulty in learning to read. Since both the slow readers and retarded children had been exposed to more schooling than the first graders, it seemed possible that re-learning rather than initial learning was involved and that the decrease in rate indicated an approach to the limit of a previously acquired reading vocabulary. It was also possible that the difficulty was due to the nature of the program or the conditions under which it was administered. In particular, the program used in this experiment resulted in much repetition of material already learned, and the half-hour tutoring sessions seemed excessively long. Both conditions were modified in later experiments.

"Therapeutic" effects of the training, indicated by the reading of words not taught, were negligible (Table 4) except for one subject in the slow-reader group whose score increased by 59 between pre-test and retention test. Since the test was a 10 per cent sample of the Gates list of 1500 words, a very large gain in reading vocabulary was indicated.

Table 4 Mean gain in words read correctly on general vocabulary test (Not practiced in experiment)

Group	*Pre-test to post-test*	*Pre-test to one month retention test*
Normal	3.8	5.8
Slow	2.5	13.8
Retarded	1.5	2.0

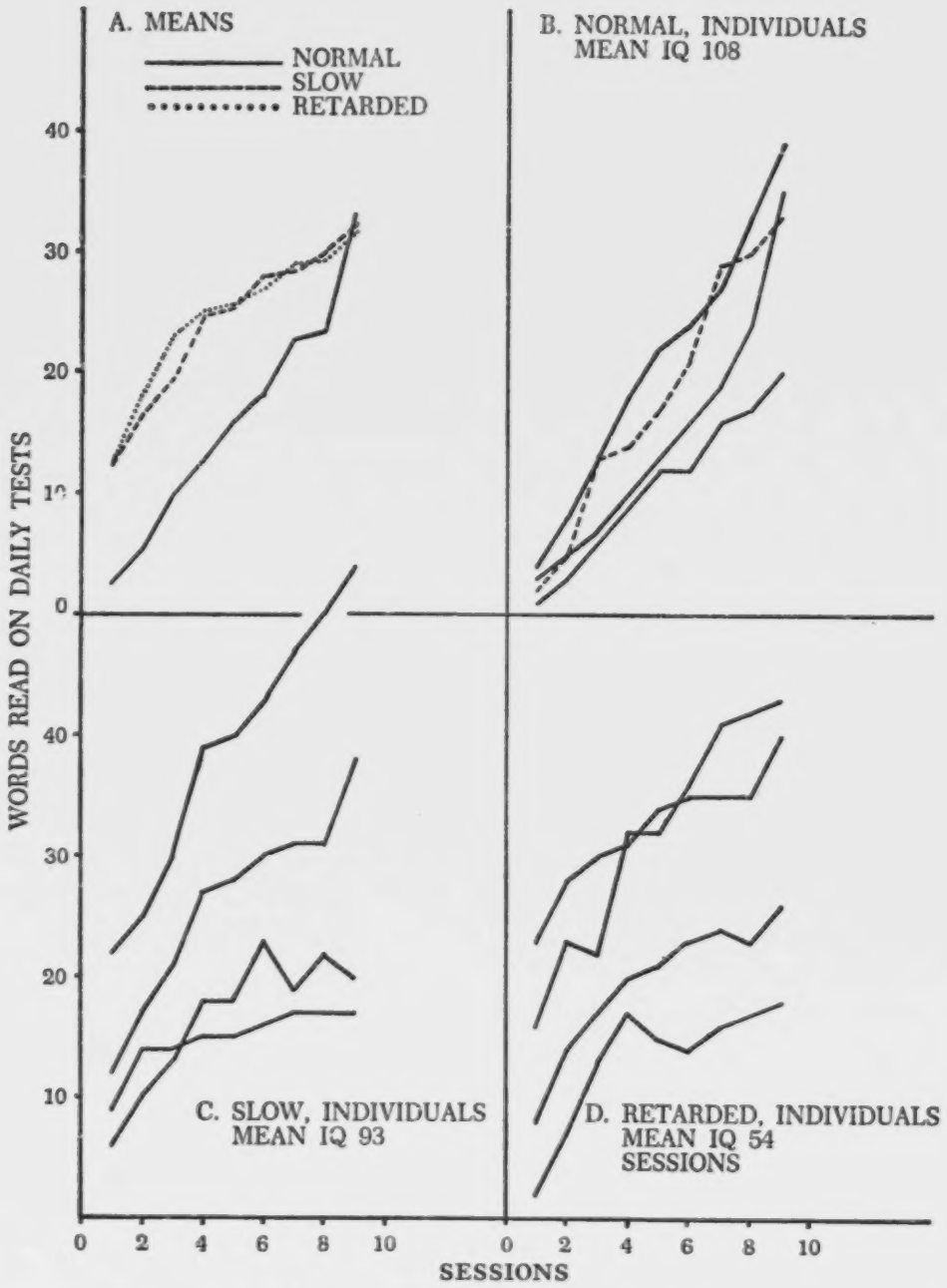


FIG. 1. Mean and individual learning curves for sight-reading for normal children, slow readers, and retarded children. Experiment III.

EXPERIMENT IV

Comparison of classroom and programed tutoring techniques

Four groups of 16 retarded children, similar to those taking part in Experiments I to III, were tested for *a*] vocabulary learned and *b*] comprehension, before and after six half-hour teaching sessions distributed through one and a half weeks. The conditions distinguishing the four groups follow:

GROUP	CONDITION
Program:	Taught individually with the Sight-reading Program.
Classroom:	Taught the same material by standard classroom procedures in groups of eight.
Alternation:	Taught in alternate sessions with program and classroom procedures.
Control:	No training between tests.

All groups were given two tests both before and after the training period: *a*] a test of the total reading vocabulary that appeared in the learning material, and *b*] a test of comprehension that involved oral questions about the meanings of new sentences constructed from words in the learning material.

Results expressed as gain in vocabulary and comprehension test scores are shown in Table 5.

Table 5 Mean gain in practiced vocabulary and comprehension test scores

Group	*Vocabulary gain*	*Comprehension gain*
Program	32.9	.9
Class	18.1	1.5
Alternation	37.6	4.1
Control	6.6	1.3

Differences between the following pairs of groups for reading vocabulary gains were significant at the .05 level: Control vs. Program, Control vs. Alternation, Class vs. Alternation. No differences were significant for comprehension gains.

EXPERIMENT V

Comparison of methods of combining classroom and program procedures

This study extended Experiment IV for an additional six sessions, giving each subject a total of four sessions per week for three weeks. Three methods of combining the program and classroom procedures were compared. The tests were the same as those in Experiment IV but were presented again as an additional post-test after the twelfth session. Experimental conditions for the four groups were as follows:

GROUP	CONDITION
P-C	Six sessions taught with the Sight-reading Program followed by six sessions in the classroom.
C-P	Six sessions in the classroom followed by six sessions taught with the sight-reading program.
A	Twelve sessions in which classroom and programed tutoring were alternated.
Control	No training between tests.

Results expressed as gains in reading vocabulary and comprehension test scores are shown in Table 6.

Table 6 Mean gains in practiced vocabulary and comprehension test scores

Group	*Vocabulary*	*Comprehension*
P-C	39.0	3.8
C-P	37.6	3.7
A	57.2	6.6
Control	12.6	1.4

All experimental groups gained significantly more in vocabulary scores than did the control group. The mean rate of acquiring new reading vocabulary by the alternation procedure was approximately nine words per hour of instruction. Mean gains in vocabulary were statistically significant for all except the control group; the difference in vocabulary gain between Groups *A* and *C-P* was significant at the .05 level. Other differences are not statistically significant.

Improvement in comprehension was statistically significant for Group *A* only, but the gain was not significantly greater than that of the control group. There were no significant differences between groups for comprehension scores. Poor comprehension under the conditions of this experiment is understandable, since at the time of the final test few children could read more than 50 per cent of the words in the comprehension test material.

Experience with the Sight-reading Program so far has indicated one obvious defect: as a learner's vocabulary increased, he often read entire sentences with perhaps a single error. In the Sight-reading Program, as presented (see Experiment III), such an error leads to Step 2, which requires practice on *all* of the words in the sentence, including those read correctly on the preceding test step. Such extensive digressions appeared to frustrate some children at a very early stage of vocabulary acquisition, and this undesirable effect increased with progress. Consequently, the Sight-reading Program was modified to minimize repetition of material already known. In later forms of the program the teaching procedures in Steps 2 and 4 were applied only to those words not read correctly on the preceding test steps. This change, based on purely practical considerations, was supported strongly by the results of the following study.

EXPERIMENT VI

Investigation of the optimal proportion of reinforcement

In extrapolating from operant conditioning experiments in the laboratory to the techniques of programed instruction, Skinner (1954, p. 94) has suggested that reinforcement should be maximized and errors minimized: "By making each successive step as small as possible the frequency of reinforcement can be raised to a maximum, while the possibly aversive consequences of being wrong are reduced to a minimum." But in our program and, in fact, in any branched program in which information or teaching steps are presented only in case of error on test steps, the principle implied here cannot be followed to its logical conclusion since 100 per cent reinforcement would preclude the presentation of any new information, in which case, nothing could be learned. But, if it is assumed that reinforcement should be maximized short of this extreme, the practical question arises: what is the

optimum proportion of reinforcement? Presumably it is near, but less than 1. Experiment VI was run to obtain an empirical answer to this question. Rates of acquisition were determined for four proportions of reinforcement, ranging from .05 to .95.

A Paired Associates Program, similar to the Picture Program of Experiment I except oral prompts replaced pictures as stimuli to evoke the correct oral response, was used. The apparatus or "teaching machine" was also similar. It was composed of a wooden screen in which words were exposed and on which a light was mounted behind a frosted glass panel. Subjects were told at the beginning of the experiment that the light meant they had read a word correctly; during training trials the light was turned on briefly after correct responses in Step 1 only.

Each of the four groups was given four training trials: 20 words were presented in each, followed by a test consisting of all of the words learned on Trials 1 to 4. The proportion of reinforcement on training trials was maintained near the required level for each group by controlling the proportion of "known" and "unknown" words included in the list of 20. Note that the proportion of reinforcement on a given trial is equivalent to the proportion of known words, i.e., words read correctly (and thus reinforced) on Step 1. This proportion was held approximately constant for each subject: on the first trial by selecting words that he had and had not read correctly on a pre-test, and on Trials 2, 3, and 4 by replacing excess words read correctly on the preceding trials by other words not read correctly on the pre-test.

A total of 41 older retardates, similar to those in earlier experiments, were assigned to four groups, each trained with a different proportion of reinforcement: .05, .35, .65, and .95. Results, which appear graphically in Figure 2 and numerically in Table 7, show an inverse linear relationship between proportion of reinforcement and number of words learned as measured by performance on the test trial.

Table 7 Proportion of reinforcement and words learned

Group	*Intended proportion of reinforcement*	*Actual mean proportion of reinforcement*	*Mean words learned trials 2–4*	*Mean words learned trial 5*
1	.05	.21	13.1	10.1
2	.35	.47	9.7	7.1
3	.65	.71	5.6	4.9
4	.95	.96	1.0	1.0

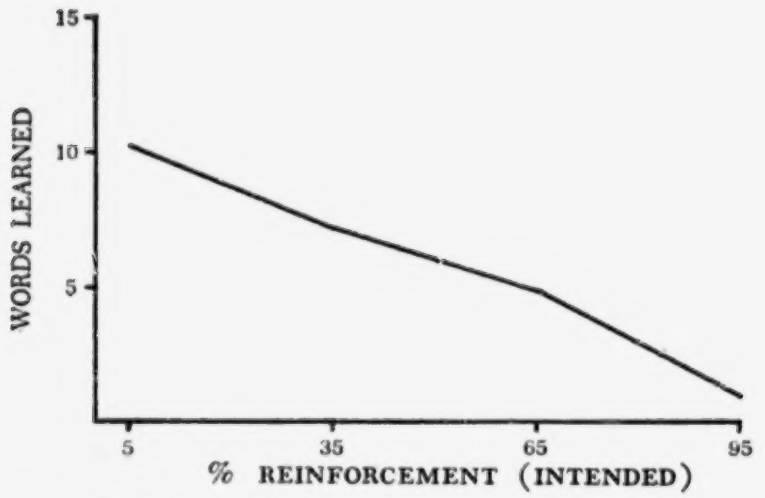


FIG. 2. Words learned and correctly read on Trial 5 as a function of proportion of reinforcement. Experiment VI.

An F of 15.6 indicated that the overall effect was highly significant; and t-tests showed all inter-group differences except for the adjacent pairs, 1-2 and 2-3, to be significant at the .01 level.

The inverse relationship between proportion of reinforcement and learning was clearly not in agreement with the theoretical expectation, although it was consistent with modifications introduced in the Sight-reading Program on the basis of purely practical considerations. These changes all had the effect of reducing the proportion of time spent in practice on known material. It was also consistent with the notion that drill is not an efficient teaching method.

The plan of this experiment was defective. Since the test trials included only words learned on previous trials, they were not comparable across groups. For this reason the experiment is being repeated with better controlled conditions, although considerations not discussed here suggest that the changes should have little effect upon the results.

EXPERIMENT VII

An extended test of the sight-reading program

A major purpose of this experiment was to evaluate a revision of the Sight-reading Program with particular concern for the feasibility of its continued use over an extended period of time. This tryout was also designed to permit comparison of the effectiveness of ma-

chine and textbook forms of the program for teaching sight-reading to slow readers in the public schools and to two groups of institutionalized retarded children differing in age and related background. The experiment was originally planned for one semester, comparing only older retardates and slow readers. However, the retardates progressed extremely rapidly (according to a presumably justifiable comparison of pre-test and performance data, they "learned" at a mean rate of 57 new words per hour of practice). Consequently, the experiment was repeated during the second semester with a group of younger retardates having less prior school experience. Results in this replication were more in accord with expectations for retarded children.

The material for the machine form of the program was printed on a paper scroll and presented one sentence at a time by a "teaching machine," similar to that used in Experiment III. Pictures appearing in the text were mounted on cards and hand-placed at appropriate times above the opening in which the sentence appeared. The material for the textbook form of the program was arranged in booklets, each containing six to eight sentences on a common theme and constituting a "story." Single sentences were reproduced at the bottom of otherwise blank cover pages which were graduated in length so that when the booklet was opened an entire story appeared, one sentence per line. Concealed beneath each cover page were five pages of the same length containing the materials for an eight-step operational program designed to teach words of the sentence not read correctly from the cover page. These materials included the sentence with and without an illustrative picture, the words of the sentence in a random order, and the words under small flaps for individual exposure. A "reinforcement box," used with both forms of the program, contained lights, separately controlled by concealed pushbuttons, behind translucent white and green panels. The children were told that the white light would appear when they read an entire sentence correctly and the green light when they read a single word correctly.

The operational program was similar to the Sight-reading Program described in the report of Experiment III, but differed in several significant details: it contained eight steps in which 3, 5, and 7 were teaching steps; the others were test steps similar to Step 1 in the earlier program. Two of these, 2 and 4, were "picture-prompted" tests in which a relevant illustration was presented with the sentence to be read. Steps 1, 6, and 8 were unprompted tests in which the sentence

was presented alone. Step 3 utilized the very common teaching device which in the laboratory is called the Paired Associates Method. Words not read correctly on the prompted test, Step 2, were pointed to singly. If the learner read the word correctly, the green light was flashed; if not, the word was pronounced by the tutor and the learner was required to pronounce it before proceeding. This step was introduced primarily for children who were able to read with some fluency. For them it served to quickly reinstate a temporarily forgotten word with a minimum of interruption to the flow of reading. For children still reading slowly, this step was likely not to be sufficient, so that they continued through teaching steps 5 and 7 (similar to Steps 2 and 4 in the Sight-reading Program of Experiment III). As indicated above, correct reading of a sentence on a test step was reinforced with a white light; correct reading of a word on a teaching step by a green light.

The reading material, which may be called the *content program* to distinguish it from the *operational program* described above, was adapted from Reader One, *A Day with the Brown Family,* and Reader Two, *Making a Good Living,* from the *Home and Family Life Series* (Bright & Mitchell, 1949). The selection contained 105 different words and a total of 327 running words. Sentence length ranged from four to ten words with a mean of 6.7. Each sentence was accompanied by a picture chosen from the original text material; in several instances, the same illustration was used with more than one sentence.

The program was administered to experimental groups during 20-minute sessions twice weekly for 12 weeks. The tutoring was carried out by two women students, college sophomores who were preparing for elementary teaching but who had had no teaching experience. Control groups were given pre- and post-tests at the same time as the experimental groups but received no tutoring.

Performance was measured in terms of the number of different new words included in sentences read correctly on Step 1 during tutoring sessions, and in terms of scores on three tests: Test I: a general reading vocabulary test constructed as a 10 per cent sample of the Gates list of 1500 words; Test II: a list of the 105 words included in the content program; and Test III: a list of the 49 sentences in the same material. All were scored in terms of the number of different words read correctly. All were used as pre- and post-tests. Test III was also administered once per week during tutoring sessions.

Six groups of 16 children each were selected from state and public schools as follows:

GROUP *OR* *Older retardates* chosen randomly from advanced academic classes (approximately third grade level) in the Training School at the Fort Wayne State School for Retarded Children. Mean CA 16–1 (Range 12–19); Mean IQ 54 (Range 41–80).

GROUP *YR* *Younger retardates* chosen from pre-academic classes (below first grade level) in the Training School. These children were chosen on the basis of teachers' judgments that their spoken language was intelligible and that they could understand the material in the content program if it were read to them. Mean CA 13–4 (Range 11–15); Mean IQ 43 (Range 30–56).

GROUP *SR-1* *Slow readers* randomly selected from pre-first grade reading-readiness classes in an elementary school of the Fort Wayne public schools. The population from which this group was selected consisted of the lower third of the kindergarten classes of the preceding year as indicated by teachers' judgments and reading-readiness tests. Mean CA 6–2 (Range 5–8 to 7–3); Mean IQ 91 (Range 76–105).

GROUP *SR-2* A second group of slow readers randomly selected from the same population as SR-1. This group served as a control group (Group SRC) during the Fall semester and was tutored as an experimental group (Group SR-2) during the following Spring semester. Mean CA 6–9 (Range 6–1 to 7–9); Mean IQ 83 (Range 62–96).

CONTROL GROUP *ORC* A second group selected as was OR. Mean CA 16–1 (Range 13–24); Mean IQ 57 (Range 47–81).

CONTROL GROUP *SRC* The children in Group SR-2, used as a control during the Fall. Mean CA 6–4 (Range 5–8 to 7–4); IQ's as above.

Reading performance scores on the three pre-tests were zero for all subjects except those in the OR and ORC groups. For the OR group, mean scores on pre-tests I, II, and III respectively were 29, 42, and 24; for the ORC group, 27, 34, and 16.

Performance during tutoring and gains from pre-test to post-test are summarized in Table 8. In this table, N is the number of subjects who remained in the experiment through the post-tests; $n > o$ refers to the number who showed gains of 1 or more on given tests. It is evident from the performance data given here and in the figures to follow that significant progress was made in reading "new" material by all groups during the tutoring process. However, the extremely rapid

gains made by the OR group, especially when expressed as rate of acquisition, led to the suspicion that the improvement represented not so much the acquisition of new vocabulary as reinstatement of prior learning or latent learning. The fact that all of the retardates had had prior schooling, often several years, supported this interpretation. Because of this, and since the concern here was primarily with the effectiveness of programed tutoring for the initial teaching of reading, there was little more to say about the OR group.

Table 8 Test scores and performance during tutoring (Word units)

		Groups					
		Experimental				Control	
		OR	YR	SR-1	SR-2	ORC	SRC
	N	10[a]	7	12	14	15	14
Total gain during tutoring	Mean	64.2	38.9	74.8	82.1		
	Range	29 to 105	4 to 105	48 to 105	56 to 105	—	—
Rate: gain per session[b]	Mean	19.1	2.1	3.3	4.6		
	Range	4.0 to 53.0	.2 to 7.0	2.1 to 4.8	2.4 to 8.8	—	—
Gain on Test I	Mean	4.7	0	.2	3.1	1.1[c]	0
	Range	−1 to 20	—	0 to 2	0 to 10	−6 to 12	—
Pre-Post	n > o	9	0	1	10	8	0
Gain on Test II	Mean	46.5	5.0	15.3	14.9	5.4[c]	0
	Range	17 to 77	0 to 11	0 to 27	0 to 45	−2 to 15	—
Pre-Post	n > o	10	5	11	13	12	0
Gain on Test III	Mean	71.7	7.1	19.0	25.1	3.5[c]	0
	Range	23 to 103	0 to 22	6 to 36	0 to 64	−2 to 15	—
Pre-Post	n > o	10	5	12	13	4	0
Transfer $\frac{\text{Test II Gain} \times 100}{\text{Total Gain}}$		72%	13%	20%	18%	—	—

[a] Two subjects who read all the words in the program on Session 1 are not included.
[b] Gain per session, based on total sessions present *or* sessions before completion of program.
[c] Difference, OR vs. ORC, Test I: $t = 1.92$ $(p > .05)$
Difference, OR vs. ORC, Test II: $t = 7.92$ $(p < .001)$
Difference, OR vs. ORC, Test III: $t = 8.30$ $(p < .001)$

The number of words read correctly by the YR and SR groups on all of the post-tests was markedly less than that read during tutoring. This was to be expected in the case of Test I because of the small overlap between the tutored and tested vocabulary, but the decrease was also large for Tests II and III. This indicates that, under the conditions of this experiment, retention or transfer from the tutoring

situation is limited. This is especially the case for the YR group which agrees with previous comparisons of normal and retarded children (Kirk & Johnson, 1951). However, the relatively close relationship between total gain during tutoring and the proportion of transfer to the tests suggests that other factors may be involved.

An analysis of variance showed differences between experimental groups in rate of acquisition during tutoring to be significant at the .001 level, but no significant effect of form (text vs. machine) and no significant interaction was found. Mean differences in rate were significant for all pairs of groups except YR and SR-1.

Individual cumulative acquisition curves for all subjects who completed the training and post-tests are presented in Figure 3. The detailed picture concurs with the averaged data given above. Both initial reading vocabulary and rate of acquisition were markedly greater for the older retardates than for the remaining groups. The younger retardates learned more slowly and the performance of the slow readers fell between those of the two retarded groups. Variability in rate was relatively greater for the retarded than for the public school children.

Individual curves indicate a relatively constant rate of acquisition throughout the period of tutoring for all but the YR group. Two of the children in this group, whose IQ's were 56 and 34, showed a learning pattern similar to that of the median slow readers (and of normal children in later experiments). However, the remaining five, whose IQ's were 56, 43, 43, 29, and 30, ceased to improve after an initial period of apparently normal acquisition. Detailed records for these children showed a stereotyped performance during the terminal period of no progress: each child read the same sentences and made the same errors repeatedly.

An important finding in this experiment from the practical point of view was the apparent effectiveness of the programed tutoring technique for the teaching of sight-reading to many children who commonly have difficulty in beginning reading. However, it clearly failed with a number of the more severely retarded children and the transfer to test situations, differing only slightly from the tutoring situation, was less than expected. Further research will be necessary to show whether modifications of the technique or the conditions under which it is applied can extend the range of children with whom it is effective or can increase the transfer of what is learned.

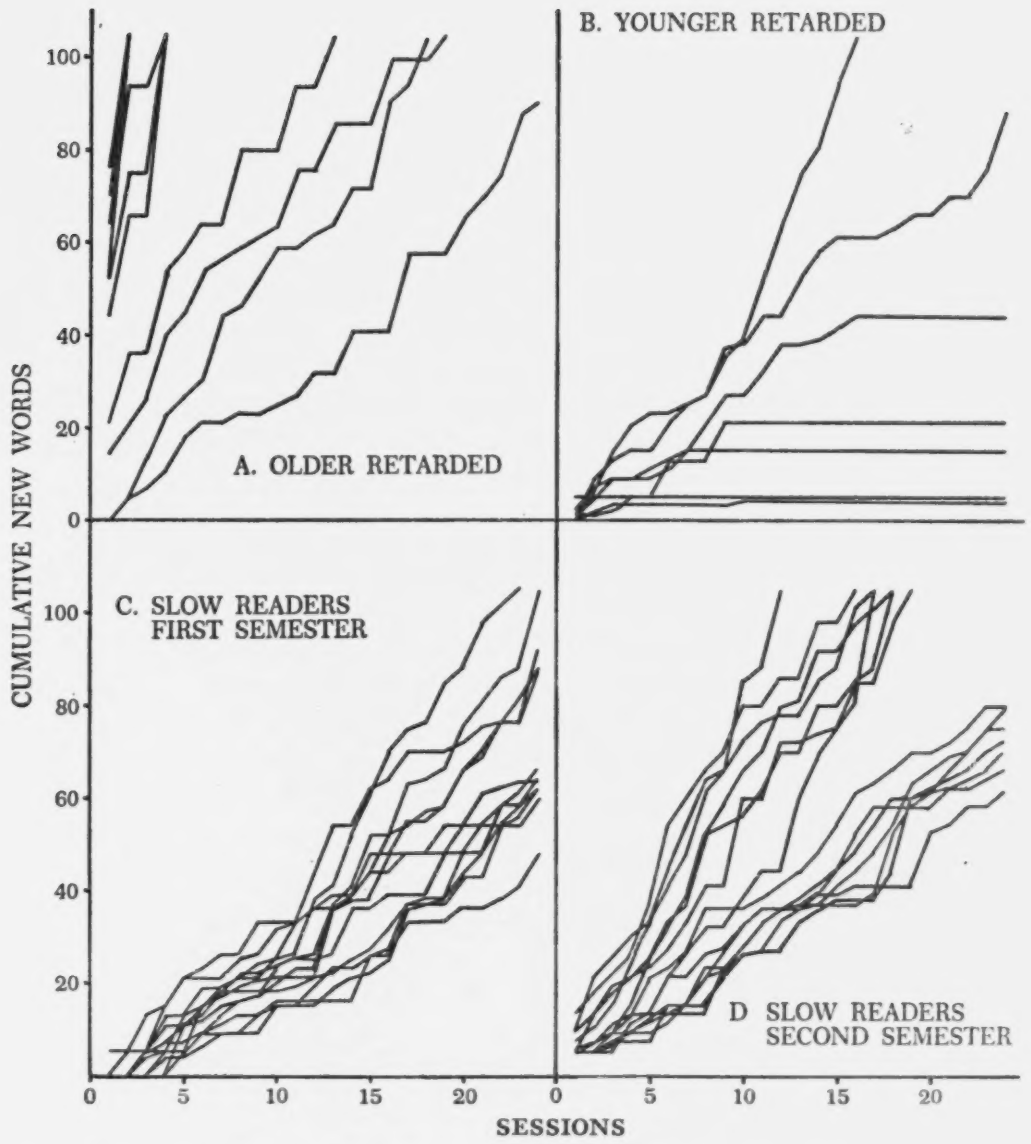


FIG. 3. New words read during tutoring: individual curves. Experiment VII.

EXPERIMENT VIII

A pilot study of three comprehension programs

The primary purpose here was to try out three programs designed to teach comprehension of simple instructions, questions, and declarative statements. These programs, interleaved with sight-reading programs, were tested under several conditions with children of a wide range of intelligence and reading-readiness as indicated by tests

and teachers' judgments. The effectiveness of the combination of programs was compared with that of classroom teaching.

The comprehension programs were constructed on the basis of a behavioral analysis of reading comprehension. Reading comprehension behavior, or, for that matter, comprehension of any verbal stimulus material except possibly that designed to evoke an emotional response, has *a*] compliance, *b*] semantic or referential, and *c*] logical or combinatorial components. To demonstrate reading comprehension the child must be able to *a*] obey printed instructions and answer printed questions, *b*] relate printed words and sentences to objects and situations (or verbal and non-verbal representations of them), and *c*] produce or identify conclusions drawn or extrapolated from combinations of printed sentences. The three comprehension programs developed for this experiment incorporated only the first two of these components.

Each of these programs began with material that was reviewed, when necessary, by use of the Sight-reading Program. This sight-reading was followed by further test and teaching steps which required comprehension. The Instruction Comprehension Program presented one-page units, each containing a picture with two or more objects, a sentence describing the picture, and a second instruction-sentence or question which could be responded to appropriately by pointing to one of the objects. The Question Comprehension Program material omitted instructions but included questions which could be answered on the basis of information in the picture. Answers were first given orally and then, after removal of a covering flap, by pointing to and reading the correct one of three printed answers. The Statement Comprehension Program was similar except that correct answers could not be obtained from the accompanying illustration, but only from a statement that preceded the question.

The material taught by the tutoring procedure in this experiment consisted of six stories of nine or ten sentences tutored with the Sight-reading Program. Each story was followed by an equal number of Instruction Comprehension Program units and ten Question or Statement Comprehension Program units. Groups taught by classroom procedures worked through the same material with the aid of a blackboard and workbooks, word-cards, etc., specially constructed for the purpose.

Two differing replications of the experiment were carried out

in two schools in areas of low socio-economic level in different cities during an eight-week summer term. The children in School T were fairly representative of such a school population (Peabody Picture Vocabulary Test IQ mean 101, Range 61–127). With few exceptions, they had had no kindergarten experience and took part in the experiment just prior to their entry into the first grade. Those in School H had completed one year of kindergarten and had been assigned to a special pre-reading class rather than to the first grade on the basis of teachers' judgments and readiness tests (Binet IQ mean 84, Range 62–112). According to recommendations in the manual for the Ginn Pre-Reading Test, which was administered to all children in the experimental groups at the beginning of the experiment, none was ready for reading instruction. Children were assigned randomly to the groups listed in Table 9.

Table 9 Description of experimental conditions

Group	*Conditions (Daily for six weeks)*	*N School T*		*N School H*	
		Initial	*Final*	*Initial*	*Final*
PrPr:	Two 15-minute programed tutoring sessions	7	7	10	8
Pr:	One 15-minute programed tutoring session	—	—	10	10
PrCl:	One 15-minute programed tutoring session and one 30-minute classroom session	7	3	10	6
Cl:	One 30-minute classroom session	—	—	10	10
ClCl:	Two 30-minute classroom sessions	7	5	10	7
Control:	No tutoring or classroom sessions	7	7	—	—

Between tutoring and classroom sessions the children were in the charge of a trained teacher instructed to provide kindergarten activities with the one exception that no printed words or letters were to be presented. Violation of this rule occurred only in the case of moving picture film titles.

No difficulties were encountered in administering the Comprehension Programs, and, except for slight changes in the mechanics of presenting the material, no alterations have since been made in them. The children appeared to be interested and for a number of them a change of behavior appeared to accompany or soon follow the introduction of the first Comprehension Program. Their interest improved; their reading appeared somewhat less mechanical; and, in one instance, a child himself identified the critical point by saying the equivalent of "Aha, now I know what you want me to do!"

The quantitative results of the experiment, presented in Table 10, are of two kinds: learning data obtained during teaching and tutoring sessions, and data obtained from pre- and post-tests.

Table 10 Mean post-test scores and gains

Measure	*School*	*Group* PrPr	Pr	PrCl	Cl	ClCl	*Control*
Gates Gen'l	H	1.0	0.3	1.2	0.1	0.3	—
Vocabulary	T	1.1	—	1.0	—	0.6	0
Test	Mean	1.1	0.3	1.1	0.1	0.4	0
Ginn Pre-	H	—	—	—	—	—	—
reading Gain	T	7.7	—	19.3	—	9.6	5.6
Program	H	14.8	7.1	23.3	9.5	14.0	—
Vocabulary	T	11.4	—	17.0	—	18.2	.1
Test Gain	Mean	13.2	7.1	21.2	9.5	15.8	.1
Comprehension	H	11.8	5.7	9.7	6.3	7.3	—
Score	T	12.4	—	11.7	—	11.6	1.3
(Post-test only)	Mean	12.1	5.7	10.3	6.3	9.1	1.3
Total Program	H	61.6	15.6	9.2	11.0	11.0	
Units[a]	T	69.3	—	31.3	—	28.0	
Read	Mean	65.2	15.6	20.7	11.0	18.1	
Mean Rate	H	1.50	.49	1.12	.44	.22	
(Units per	T	1.64	—	1.89	—	.56	
Session)	Mean	1.56	.49	1.37	.44	.36	
Final N	H	8	10	6	10	7	—
	T	7	—	3	—	5	7
	Total	15	10	9	10	12	7

[a] In this experiment program units in the Sight-reading Program were single sentences.

For tutored students, detailed individual records of progress through the program were available; classroom performance measures are means based on the teachers' reports of the portion of the program (text) completed by the final session of teaching. Rates for classroom

groups were computed on the assumption that the children had been present on 25 of the 30 teaching days; for tutored children, rates were based on the number of sessions each child was present.

The tutored groups consistently read more units of text than the comparable classroom groups. Note that if teaching *time* is considered (see Table 9), the differences must be larger than those shown in Table 10. As might be expected, children tutored twice daily completed more units of program content than those tutored once daily. Rates (units per session) are also higher for the PrPr groups but differences in rate are not statistically significant. There is a marked and obviously significant difference in the rates at which children in tutored and classroom groups progress through the program content. The detail of this difference is fairly represented in Figure 4, which shows individual curves for the PrPr group (solid lines only) and a

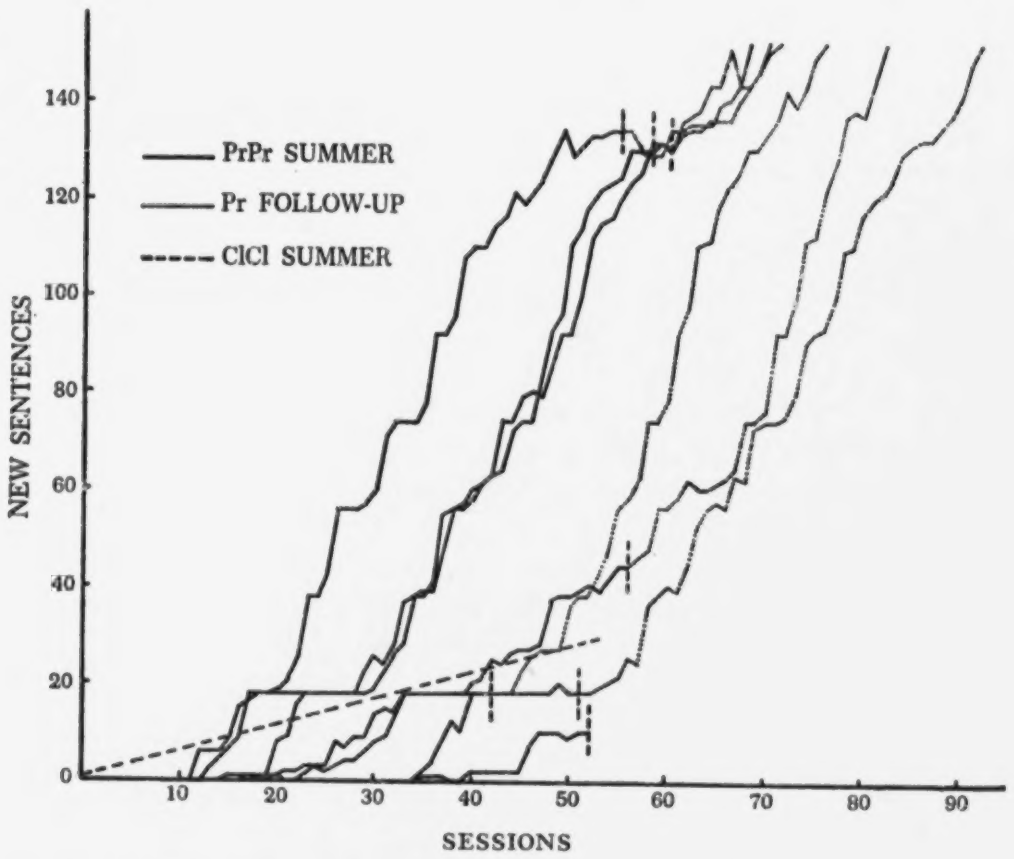


FIG. 4. Individual curves for children tutored twice daily, with post-experiment follow-up, and estimated maximum performance curve for the group taught twice daily in the classroom. Experiment VIII.

constructed mean curve for the ClCl group at School T. It should be mentioned that the latter represents a maximum rather than an average. No child in the classroom group read more than the curve indicates; a few read less. Three children in the tutored group read less than the classroom maximum: one somewhat more, and three read more than four times as much material. It would appear that the classroom procedure enforced conformity to a norm, to the disadvantage of the faster learners.

A question arose concerning the performance of the slower learners in the tutored group and it was decided to continue the tutoring of the children in the PrPr group until all of them had completed the available material. Beginning approximately one month after school opened in the fall, tutoring was continued for six of the children, one session per day in their homes. The seventh child was excluded at his parents' request because of illness. The results of this follow-up, shown as dotted lines in Figure 4, indicate that with continued tutoring the slower readers eventually attain rates comparable to those of the faster learners. This outcome was encouraging, but further research is necessary for an adequate interpretation. The number of cases was very small and unfortunately the slowest reader was not included. Further, at least three conditions changed between the experiment proper and the follow-up: the number of daily sessions, the environment in which tutoring occurred, and the nature of the concurrent classroom instruction.

Interpretation is further complicated by discrepancies between performance during tutoring and on subsequent tests—the correlation is far from perfect. Vocabulary and comprehension scores on posttests are considerably below what would be expected if the children had retained all of the learning they had demonstrated in the tutoring and classroom sessions; only in the case of the Comprehension Test is there much consistency between test scores and the amount of material covered during teaching sessions.

Gains on the general vocabulary test are small and intergroup differences are negligible. This is to be expected from administration of a wide-range test at this stage after relatively limited training by the sight-reading method. This test was included only as a precaution, to catch the occasional six-year-old with a large reading vocabulary. So far none have been caught. Gains on tests of reading readiness and vocabulary included in the program were largest for the

group taught in alternate sessions by the programed tutoring and classroom procedures. These results agree with those of Experiment IV in favoring a combination of Programed Tutoring and classroom teaching. Together with evidence obtained in other experiments of this series, the results also suggest that teaching a child to read provides excellent training in the skills required by reading-readiness tests. Although differences are not statistically significant, the high scores obtained on the Comprehension Test by the PrPr groups confirmed a favorable impression of the effectiveness of the Comprehension Programs.

EXPERIMENT IX

Tryout of a word analysis program

In the experiments reported so far, which were brief and involved tutoring at only the earliest stages of reading, sight-reading methods were found to be satisfactory. However, since these methods may not be the most efficient for building large reading vocabularies in English and since, in any case, there is a strong public prejudice against their exclusive use, word analysis or phonics programs were developed. The purpose of Experiment IX was to try out a first program of this kind and, in accord with previous practice, it was tested under several conditions.

In preparing for the development of this program the work of linguists and educators was examined to obtain information concerning the grapheme-phoneme correspondence rules for the English Language and their utility. A superficial search uncovered nearly three hundred rules. All of these may be necessary to ensure proper pronunciation (and spelling) of English words in print, but even these are not sufficient. In any case, proper pronunciation is not the primary object of using grapheme-phoneme correspondences in the teaching of reading. Given printed or written words, preferably in context, the beginning reader learns implicitly or explicitly to use some of the rules and produce sounds similar enough to the spoken forms that they can be recognized. It is assumed, of course, that the necessary words are in his oral or aural vocabulary. For this purpose, some rules are more useful than others. Especially when supplemented by context, a small number of rules is sufficient to identify a relatively large proportion of English words.

It is desirable for teaching to order the grapheme-phoneme correspondence rules in terms of their utility and regularity. A useful bibliography on this topic assembled by Carrol (1963) includes the work of Clymer (1963), who has done the most systematic work on utility, and other references (Hanna & Jacks, 1962; Venezky, 1962). The latter indicates that similar but more extensive investigations utilizing computers are under way, but this work is not yet complete. The Word Analysis Program, like most phonics-oriented reading texts, was based on an arbitrary selection of rules influenced by a general knowledge of their utility.

The program was designed to induce the discovery and practice of rules for pronunciation of eight consonants in initial and terminal positions and five vowels, short sound only, in CVC trigrams. The operational program began with a test step in which a presumably new word was presented as a problem that could be solved by correct pronunciation. Success was reinforced and followed by presentation of the next problem word. Failure was followed by cumulative presentation of additional information in the form of other words which exemplified the component grapheme-phoneme correspondences required to solve the problem, i.e., to read the problem word. These words were already known or were taught or reviewed by a form of the Paired Associates Program. Successive increments of information were alternated with further test steps. After continued failure, the tutor required the child to read the word by means of a forced multiple choice procedure and then proceeded to the next problem. The unsolved problem was presented again later. This portion of the program was systematically supplemented by the sight-reading of rhymes, jingles, etc., containing words that included components of the problem words.

The operational program just described exemplifies a technique called *brightening* or *reverse fading*. It is the inverse of the now common programing procedure, fading, in which a stimulus definitely adequate to evoke the required response is presented and then gradually diminished until only a previously inadequate stimulus, e.g., the problem, remains. Brightening, on the other hand, begins with a presumably inadequate stimulus, the test or problem, and adds increments of stimulation or information until the appropriate response occurs. In a sense, all program branches and branched programs are examples of brightening: they begin with a test, ideally add only such increments of information as are necessary, and terminate when the learner dis-

covers the correct response. The stimulus-response paradigm for brightening, it may be noted, is an abstract description of the "discovery method" currently being recommended for classroom teaching.

The general conditions of the experiment and the population of children were similar to those of Experiment VIII. Two groups of children were assigned randomly and tutored in two 15-minute sessions daily for six weeks. As the experiment was planned, treatments of the two groups differed in the sequence of program presentation. The first session each day in Group A was devoted to Sight-reading and Comprehension Programs as in Group Pr of Experiment VIII; in the second session the Word Analysis Program was presented. In Group B, tutored twice daily, sections of the Word Analysis Program each followed the completion of a 9- or 10-sentence story taught with the Sight-reading Program and its associated Comprehension programs.

As a formal comparison of two procedures Experiment IX was a failure, although in other respects it was one of the most valuable in the series. After relatively few tutoring sessions it became apparent that most of the children were not prepared for the Word Analysis Program and that the experiment was too short to include both preparation and sufficient time on the program to evaluate it. The reaction of many children was generally negative and in some cases hostility began to develop and generalize to other programs. For these reasons, the original plan was abandoned and it was decided to take advantage of the availability of the children to test informally a number of variations in the tutoring procedures of the Sight-reading and Word Analysis Programs.

A few of the faster readers were continued on the Word Analysis Program without difficulty. The quantitative results indicate that the program does teach. With minor changes the program was retained for use in later experiments, but, largely because of the reaction of the children, an entirely new program is being constructed. Changes were also made in the Sight-reading Program. One, of some importance, had the effect of further reducing repetition of material already learned. The original program repeatedly presented every sentence in a 9- or 10-sentence story until all were read correctly in succession; the revised program omitted sentences once they were read correctly until the last remaining sentence in a story was read correctly, after which all sentences were re-presented. This procedure was repeated until all

sentences were read correctly and consecutively in a single representation.

This procedure imposes very strict conditions for progress through a book or content program. It is, in effect, a criterion of perfection—the child must read nine or ten sentences consecutively without error. The program provided for one exception: when a single error was repeated a (precisely specified) number of times, the program was continued as though the error had not occurred. Such exceptions, labelled with obvious implications as "blocks," were very rare and in every case the blocks disappeared later without special treatment. This criterion may seem excessively strict, especially later when its effect is to require errorless reading of 10 to 12 pages, but after careful observation of its effects no reasons have been found to change it.

EXPERIMENT X

A preliminary field test of program tutoring as a supplement to classroom teaching

Up to this point actual reading curricula have not determined the specific content of the tutoring programs used in these experiments. In some cases, the tutored children were not in school or not being taught to read; in others, the tutoring content programs were independent of the concurrent school curriculum; and, in still other cases (specifically Experiments IV, V, and VII), the classroom was organized as a part of the experiment and the classroom teacher taught material assembled primarily for tutoring purposes. However, in Experiment X the program content, except for word analysis, was determined by the reading curriculum of the school system in which the experiment was done. The operations of the Sight-reading and Comprehension Programs were applied to the content program defined by the Pre-primers, Primer, and First Reader of the Ginn Basic Reader Series (D. H. Russell et al., 1961).

The experiment compared the performance of two groups during the first semester of the first grade. Their performance was measured primarily by published tests designed for use with the basic readers. All of the children had had kindergarten experience. None were repeating the first grade. The experimental group was a class of 39; 34 remained through the post-tests given at the end of the semester. The control group, selected from four other classes in the same school,

contained 34 children post-matched individually on the reading score of the Metropolitan Readiness Test (given by the teachers at the beginning of the semester). In post-matching, control subjects were selected from a pool of children who had been given the necessary pre- and post-tests to match the experimental subjects remaining when the experiment ended. In the control classrooms no changes were introduced in customary teaching procedures except to tell the teachers involved about the experiment, that the reading performance of their pupils would be compared with that of the experimental group at the end of the semester, and to provide them with alternative forms of the post-tests to be used for practice with the kinds of items included. Conditions in the experimental group classroom were as similar as possible to those in the control group except that during the morning hours each child was taken out of the classroom for two 15-minute tutoring sessions per day. The two sessions were separated by at least one hour and were so scheduled that they ordinarily occurred at times when the child would have been working individually on reading. Thus, the tutoring supplemented, rather than replaced the teacher's instruction in reading. Since eight to ten children were out at one time, the number of children remaining in the classroom was approximately the same as in the control classrooms which had smaller enrollments. Tutoring was continued for 12 weeks, preceded and followed by testing periods.

Since this experiment was considered to be a field test in which administrative questions were important, it should be mentioned that the tutors were housewives, most with children in school, recruited through an announcement in the PTA newsletter at the beginning of the year, and paid at the rate of $1.50 an hour. All had completed high school, some had college work, but none was a trained teacher. Several were sufficiently interested by their tutoring experience that they are planning to become teachers.

The tutors were given approximately 12 hours of training in addition to supervision of their work after the experiment began. A *Tutor's Guide* was provided which described the general pattern and rules followed in all programs, the nature of each program, and detailed procedures for each step in tutoring and for recording. Testing procedures and the Sight-reading Program were taught by means of reading, lectures, demonstrations, and practice on other tutors in two three-hour meetings before the experiment began. The Comprehension and Word Analysis programs were taught in two subsequent three-

hour sessions. This training seemed to be sufficient when supplemented by careful supervision, although some difficulty was encountered with recording procedures which were more detailed than would normally be required for tutoring alone. It is the investigators' impression that conscientious adults with more limited educational background–or even children–could be trained as tutors if the recording necessary for research purposes was omitted.

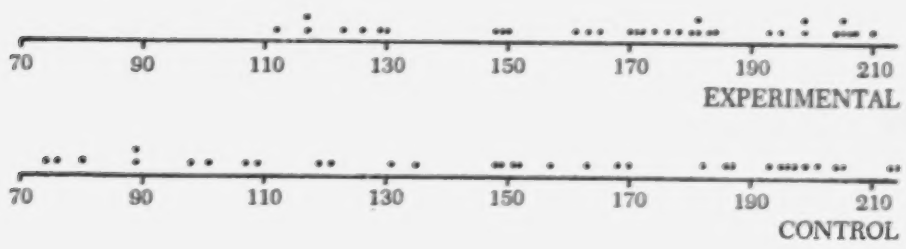
During a three-week period between the last tutoring session and the end of the semester the following tests were administered to both groups: *a*] the Ginn Pre-primer and Primer Achievement Tests, administered by the teachers in their own classrooms to groups of eight to ten children, *b*] the same tests administered individually by the tutors, and *c*] a specially constructed Word Recall Test. This latter test, administered individually, was similar to the Word Recognition sub-test of the Ginn Test, but required oral sight-reading rather than multiple choice responses. A comparison of the performance of the experimental and control groups on these tests and on the reading readiness test used for matching is shown in Table 11. The Total Ginn Score is the sum of the scores on the individual and group administration of the Pre-primer and Primer tests; the Total Word Analysis Score is the sum of the scores on the two administrations of the Initial Consonant and Rhyming sub-test scores on the Ginn Primer Test; and the Word Recall Score is based on a single administration of the Word Recall Test, which included 15 words selected randomly from the Ginn Primer vocabulary, excluding words on the Word Recognition sub-test. In all three measures of reading performance, scores are significantly higher for the experimental group.

Table 11 Comparison of groups on the matching variables and reading achievement test scores

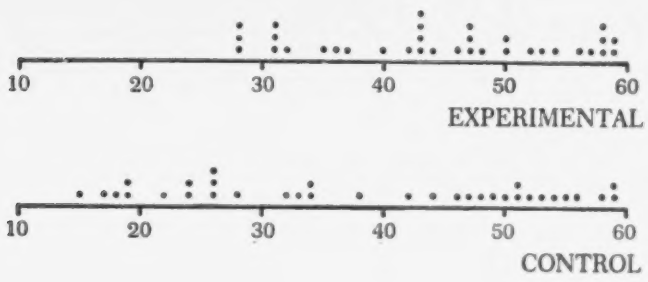
Measures	*Mean Scores*			
	Experimental	*Control*	*t*	*p*
Metropolitan Readiness Test, Reading Score (Matching Variable)	48.5	47.3	.84	>.05
Total Ginn Score	168.4	151.4	2.22	<.05
Total Word Analysis Score	44.5	38.5	2.32	<.05
Word Recall Score	13.2	10.6	4.06	<.01

Score distributions for the experimental and control groups are shown in Figure 5. It is evident that the tutoring was effective with the slower readers. This fact was recognized by the teacher of the

A. TOTAL GINN TEST SCORES



B. TOTAL WORD ANALYSIS TEST SCORES



C. WORD RECALL TEST SCORES

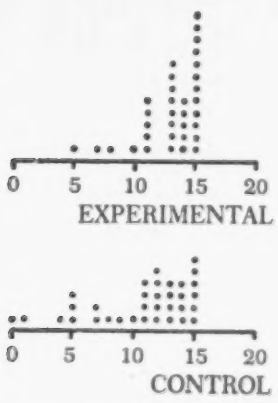


FIG. 5. Distribution of scores on a general reading test, a word analysis test, and a word recall (sight-reading) test for experimental and control groups. Experiment x.

experimental group who reported shortly before the tests were administered that in the same class without tutoring she would have expected about ten failures; instead, there were four and their performance was more nearly satisfactory than ordinarily would have been expected. This description is almost perfectly reflected in Figure 6 which shows

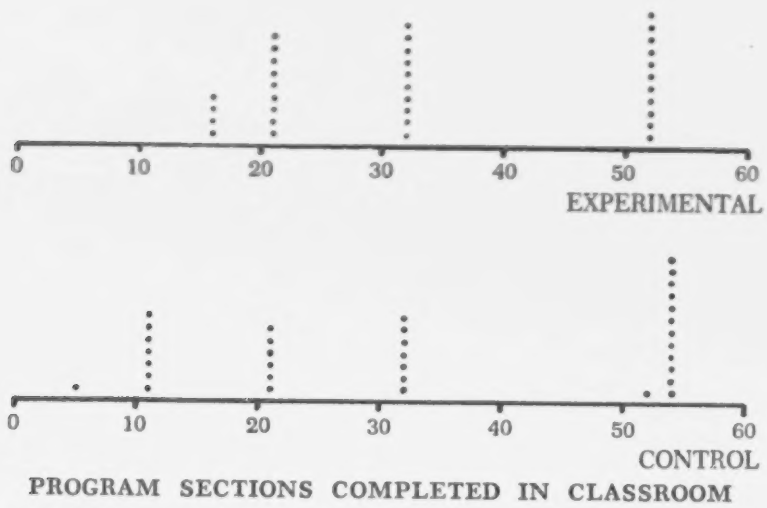


FIG. 6. Reading progress of experimental and control group children in their respective classrooms at the end of the semester as reported by their teachers. Experiment X.

the progress made in reading in the classrooms by both groups as reported by the teachers at the end of the semester for children in the experimental and control groups.

There is some indication in Figure 5 that the performance of faster readers was also improved by the tutoring but, unfortunately, neither the Ginn Tests nor the Word Recall Test was adequate to discriminate at the upper end of the distribution. In all three measures the scores were massed near the maximum possible score.

Experiment X also provided additional information concerning the effectiveness of the Word Analysis Program. Table 12 shows the proportion of problem words correctly identified by word analysis techniques by ten children who completed five or more sections of this program before the end of the semester. Although few children reacted favorably to this program, it is apparently an effective teaching device.

The data presented so far suggest strongly that programed tutoring is an effective supplement to classroom teaching, but this conclusion may be questioned since teacher variability was not properly

Table 12 Mean proportion of problem words correctly recognized by use of words analysis techniques by the ten children who completed five sections of the word analysis program

	Section					
	1	*2*	*3*	*4*	*5*	*6*
Number of Problems	3	3	4	8	8	—
Proportion Correct	.20	.37	.65	.68	.79	—

controlled. An extensive study including a more adequate sample of teachers is being planned.

The data of this experiment also illustrate the potential value of programed tutoring as a research instrument. For this purpose a detailed study of Figures 7A and B is useful. Figure 7A presents indi-

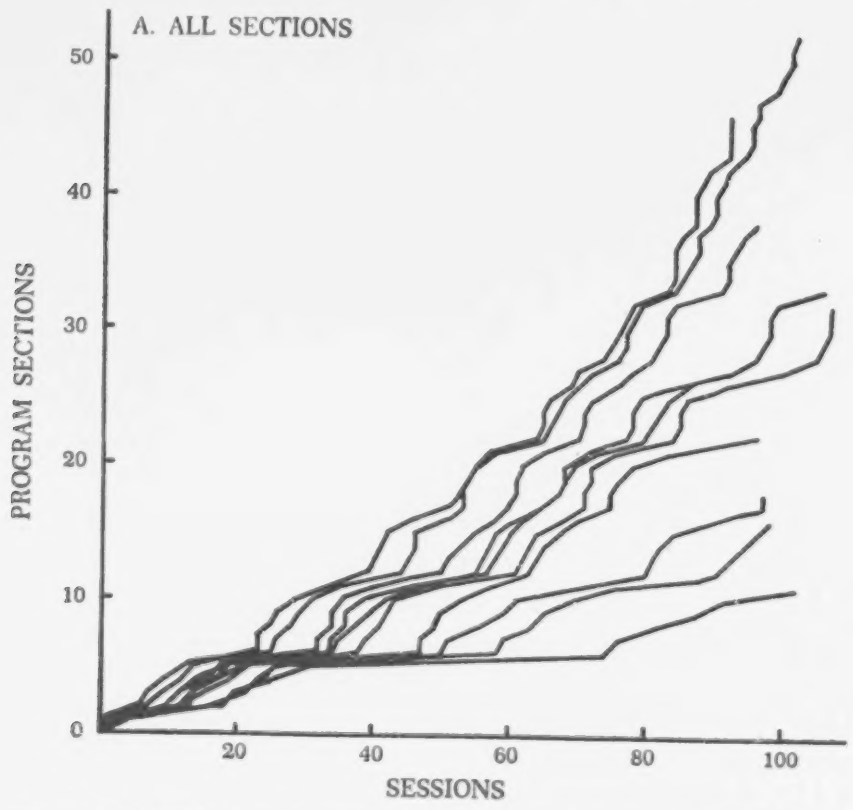


FIG. 7. A. Individual curves showing progress during all tutoring sessessions for the ten children whose terminal progress differed most.

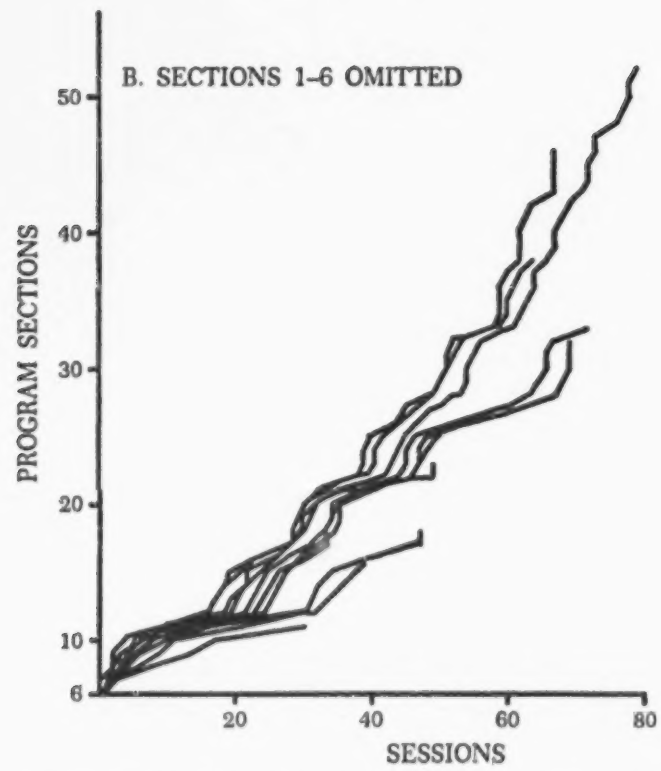


FIG. 7. B. Same data showing progress after completion of Program Section 6. Experiment X.

vidual learning curves for the ten children in the experimental group who differed most from each other in the amount of programed material completed during the semester. Units on the ordinate are arbitrarily specified sections in the programed sequence; units on the abscissa are tutoring sessions at which a child was present. The programed sequence begins with ten words taught with the Paired Associates Program, followed, with some variation, by a series of cycles, each beginning with a ten-unit section of the Sight-reading Program, followed by three sections of Comprehension Programs, and, beginning with the second cycle, by one section of the Word Analysis Program. Details of the sequence are given in Appendix II.

Of special interest is the uniformity in the pattern of the curves for most of the children, indicating that, complex as the overall process of learning to read may be, it is highly determined—when the conditions of learning are controlled in detail the learning behavior is controlled in almost equal detail. This fact holds promise for future teaching research; it suggests that a microscopic study of the learning

process in a teaching situation (which programed instruction techniques make possible) can make significant contributions to the technology of teaching.

The data represented in Figure 7A may be used for this purpose. Although the pattern is similar for all children, there are variations in overall rate–some of the children learn far more slowly than others. One might wish to attribute these differences to pre-experimental factors beyond the experimenter's control, but there is evidence that some of the variation in performance can be attributed to the experimental conditions. The largest differences between the children's rate of progress develop in the second section of the Sight-reading Program, Section 6 (see Appendix 1). Examination of the content program and consultation with tutors suggested that some children had difficulty in completing the section because of a change in the length of the unit (for a definition of a unit, see Appendix 1). At the beginning of Section 6 the units sharply increase in size from two short lines to seven or eight longer lines–a unit here being the amount of material on a page in the first two Ginn Pre-primers respectively. The difficulty, however, cannot be attributed solely to the size of the unit since it does not occur in reading the third Pre-primer or in later sections of the Sight-reading Program in which units are even larger.

When the large individual differences associated with Section 6 are excluded, as in Figure 7B, the uniformity of pattern becomes even more apparent, but small individual differences still remain. These are associated almost entirely with Program Sections 11, 12, 17, 18, 22, 28, and 33. Of these, Section 11 is the beginning of the Word Analysis Program, Section 18 is the beginning of the Story Comprehension Program, and the remainder are sections of the Sight-reading Program. On the assumption that any teaching procedure is defective if it makes progress difficult for some children, these sections need further attention.

Figure 8 compares the progress of all children in the experimental group in their classroom reading groups and in their tutoring sessions. Classroom progress was determined from teachers' reports of book and page completed by each classroom reading group; comparable data for tutoring progress was obtained from records of the investigators. At the end of the semester the slower readers had read as much material in the tutoring sessions as in their respective classroom reading groups; the faster readers had covered less in tutoring sessions

than in their classroom reading groups. Is this discrepancy good or bad? Is the classroom progress based on superficial coverage? Is the tutoring holding children back unnecessarily? Answers to these and similar questions are complex, but they can be obtained with further empirical research.

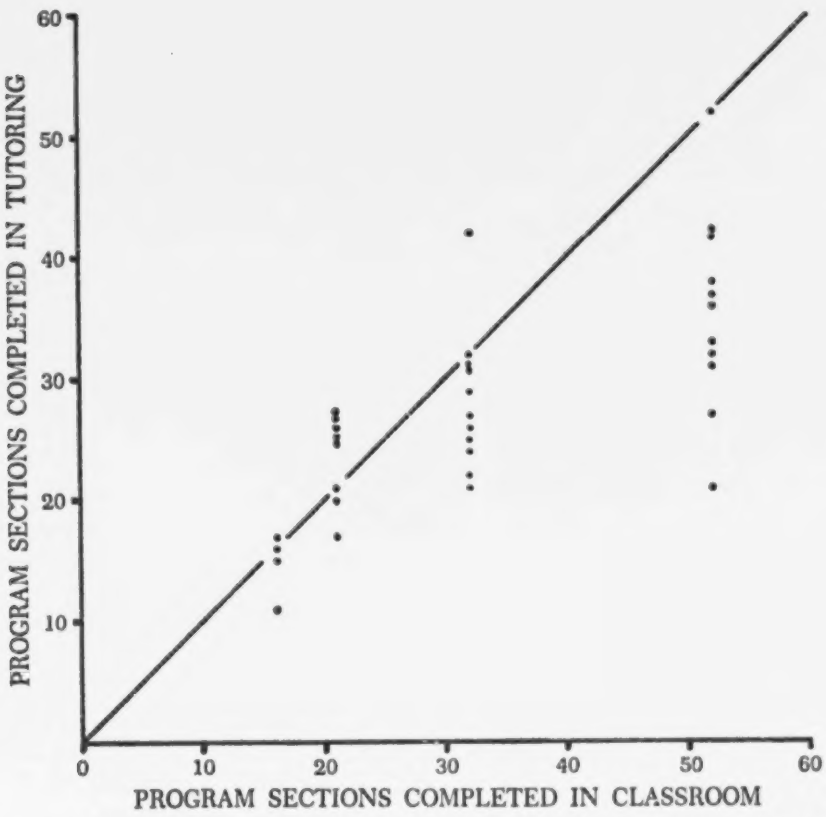


FIG. 8. Comparison of progress in reading in the classroom and in tutoring sessions. Experiment X.

Summary of experiments

Experiment I showed relatively rapid acquisition of a reading vocabulary by retarded children taught with a simple paired associates program.

Experiment II showed that retarded children, using a simple tutoring program, could teach reading vocabulary effectively.

Experiment III indicated practical effectiveness of a sight-reading program that taught reading vocabulary in a sentence context

for tutoring slow readers and retarded and normal children. First evidence of a "therapeutic effect" was obtained.

Experiment IV indicated that programed tutoring in combination with standard classroom teaching was more effective than classroom teaching alone, and probably more effective than programed tutoring alone.

Experiment V indicated that frequent (approximately daily) alternation of programed tutoring and classroom teaching was more effective than less frequent alternation.

Experiment VI, using a paired-associates program, showed an inverse linear relationship between proportion of reinforcement and rate of acquisition of reading vocabulary, indicating that the occurrence of errors is not necessarily undesirable.

Experiment VII demonstrated effectiveness of a revised sight-reading program for teaching reading vocabulary to older retardates, slow readers, and some young retardates beginning reading instruction. Failure or very limited success was attained with other young retardates.

Experiment VIII showed practical effectiveness for a public-school population of tutoring programs requiring reading comprehension. Evidence was obtained that transfer to test situation from tutoring or classroom teaching was small, but that it was greater in the case of a combination of the two techniques. Evidence suggested that with continued tutoring slower readers attain rates comparable to those of faster learners.

Experiment IX was a tryout of a word analysis program that indicated defects needing revision.

Experiment X was a field test of a composite sight-reading, comprehension, and word-analysis program that indicated its effectiveness as a supplement to classroom teaching. Evidence was obtained for importance of details of the teaching process in determining the child's rate of learning a complex skill, namely, reading.

Conclusions

These conclusions are based on examination of individual performance records, on statistical analyses of the results of single experiments, and on experience broadened by the process of trial and error in the series of experiments as a whole. In most instances, the conclusions clearly follow from hard data; in some, the experimenters

simply report impressions or opinions that have been strengthened or weakened by what has been observed, in which case reservations are indicated. The doubtful conclusions are often of greatest interest, and it is these that pose questions to be answered by further research.

Conclusions supported by statistical evidence include the obvious one that programed tutoring does teach. Combinations of programed tutoring with classroom teaching are more effective than classroom teaching alone; and, almost certainly, although the evidence is less clear, more effective than programed tutoring alone. In combining the two techniques there is an optimum frequency of alternation which, at the moment, is believed to be near once daily. In addition to teaching, there can be a "therapeutic" effect–programed tutoring reinstates effects of earlier learning or exposure to earlier teaching that are not otherwise apparent in the behavior of the children involved. In the programed tutoring situation children demonstrate abilities that they do not show in the classroom. There is some evidence, limited to a few cases, that the favorable effects can extend to attitudes and behavior outside the classroom.

There are large and significant differences in the mean rates at which children of different chronological ages, educational history, and other characteristics learn to read with programed tutoring. There are also individual differences, to the extent that there is overlap between the fastest and slowest groups tutored, but these differences are larger at the beginning of tutoring than later. There is some evidence that after an initial period of varying length in which individual differences are prominent, most children come to learn at about the same rate as the faster learners. With the exception of a few severely retarded children (2–3 per cent of a sample heavily weighted with retarded children), there have been no failures. With these exceptions, the more than 400 children tutored have learned to sight-read and, when this was required by the program, demonstrated comprehension of what they had read. The case is not yet complete, but there is reason to doubt the currently common belief that many children fail to read for physical reasons, and to suspect that many of these failures can be attributed to conditions necessarily or unnecessarily associated with group teaching in the classroom or with pre-school environment.

Much has been learned, mostly through trial and error, about the technique of programed tutoring. This ranges from specific bits of know-how to more general information which may have application

to the teaching of reading by any method. The programs described in this paper can be presented and recorded satisfactorily after about 12 hours of training by tutors with a high school education. Surprisingly, it was found that changing tutors, which was done for all children during the eighth week in Experiment X, had no apparent effect either on the performance of the children or their reaction to the tutoring situation. It was known that tutors and details of their tutoring techniques differ—their behavior is not fully controlled by the programs—but so far no significant effects of these differences have been detected. The optimal duration of tutoring sessions appears to be fifteen minutes. Children's attention can be maintained for this interval, and it permits scheduling three sessions per hour, allowing free time for necessary bookkeeping and miscellaneous interruptions.

The form and sequence of programs have undergone progressive changes which have usually occurred between, but sometimes within, experiments. This evolution will almost certainly continue, although the overall program appears to be satisfactory from a practical point of view (at least until the next experiment). Modifications introduced so far were remedies for rather obvious defects, but it seems likely that later changes in programs will require more refined justification.

Looking back over the series of experiments, many of the changes appear trends, some of which may continue. Pictures, which were important components of the first program, are disappearing or functioning with a few exceptions only as incidental illustrations or entertainment breaks that provide time for recording between tutoring units. They may be necessary in classroom instruction where catching and maintaining the attention of children is critical, but this does not seem to be a serious problem in programed tutoring. Here pictures are more likely to distract or to provide cues for memorization, which produces the appearance, but not the reality of reading. Pictures no doubt have a useful function. However, except in comprehension programs, effective means of using them in programed tutoring have not yet been developed. Another obvious trend is the progressive reduction of repetition. Experiment VI provided objective support for this kind of change, which had been introduced in earlier studies on the basis of more intuitive evidence. The reduction of repetition has been accomplished by a greater use of test steps in which success is followed by presentation of new material or of a new problem. It might seem that

this change would eliminate the review of already learned material but this is not quite the case. Review of old material occurs, but chiefly in new contexts. Another trend is the increased use of context. For example, the Sight-reading Program which teaches words in the context of sentences is largely replacing the Paired Associates Program. A similar change is being introduced in the new Word Analysis Program.

Not only the form, but the sequence of programs is undergoing change. Sight-reading appears to be a satisfactory introduction to reading without prior preparation. The Paired Associates Program is now used, if at all, only when it is desirable to teach a small special vocabulary quickly. Since sight-reading clearly benefits from comprehension, the Comprehension Programs are moving forward in the sequence. Word Analysis, on the other hand, seems to benefit from preparation in both sight-reading and comprehension, so that in the next experiment the Word Analysis Program will appear later in the sequence.

Assuming that Programed Tutoring is a technique that can improve the teaching of elementary reading, how can it be most effectively used for this purpose? The answer to this question involves administrative and economic as well as pedagogical considerations. In this regard, the term "tutoring" immediately raises the question of practicality, following the natural assumption that tutoring is an art requiring a high degree of training. No one doubts that skilled teachers tutoring one child at a time could improve on the results obtained by group teaching in the classroom. The problem arises because enough teachers with adequate training are not available for individual tutoring even if it were economically feasible to use them in this way. As Bertrand Russell (1926, p. 15) stated forty years ago: "However excellent might be the results of such a system, no man with a modern outlook would give it serious consideration because it is arithmetically impossible for every child to absorb the whole time of an adult tutor. The system is therefore one which can only be employed by a privileged caste; in a just world, its existence would be impossible." As tutoring is traditionally viewed, it is, as Russell indicates, impractical for general use, but the use of Programed Tutoring, which incorporates some of the advantages of the tutoring system, is not similarly precluded by either the economics or the arithmetic of the teacher shortage. In the form of Programed Tutoring, effective individual teaching

can be done efficiently by persons with training far short of that required of professional teachers, and very likely by some whose educational level does not equip them today for other jobs.

In its present form Programed Tutoring seems to function best as a supplement to classroom teaching. It needs modification if it is to be used effectively with severely retarded children. It is not yet certain whether the technique will be as useful with children who learn to read without difficulty in the public school classrooms as it is with those who do not. It is expected--in fact, in a few cases it has been found--that Programed Tutoring is useful in meeting the "drop-in" problem, the increasingly serious problem of children who change schools frequently and often do not bring with them adequate records of their previous classroom progress. Such children benefit especially from individual teaching. It is possible that Programed Tutoring may be adapted for remedial work with older children or for teaching special groups such as the deaf. These and similar questions concerning the best use of Programed Tutoring will require further research.

The comments so far in this section have emphasized practical aspects of Programed Tutoring which are relevant to the first of the two goals; namely, the development of a practical technique that can improve the teaching of elementary reading. Although the technique and the knowledge of how to use it can certainly be improved, this first goal has been achieved.

The second aim of this research was to develop an adequate instrument for research in problems of teaching. A number of writers have suggested that whether or not programed instruction techniques prove to be practical for routine teaching purposes, their potential contribution to educational research and to the development of a science of teaching is very great. For example, Stolurow states:

> The main staying quality of programed instruction that will be recognized more and more is its capability of controlling conditions which heretofore it was not possible to control. With programed instruction and machines, it is possible to be quite explicit about either a method or a teaching sequence. Added to this advantage is that of reproducibility of the conditions. They make it possible to study teaching itself in a way that we could not do in the past. Involved is the possibility of doing research on methods independently of the teacher's personality; later on we can study the methods when combined with different personalities to determine what happens to their effectiveness. While there has been considerable interest in this problem in the past, up to now, the capabil-

> ity for studying it did not exist. Since it does now exist, the prediction is that we will see studies of how these two sets of variables interact with one another. This will make a science of teaching a genuine possibility.
>
> This leads to the next prediction that the teaching machine will contribute to a theory of teaching. As a research laboratory, the teaching machine has the potentiality of providing the necessary controls for studying variables of teaching strategies, and so I predict that we will see one or more theories of teaching emerge in the near future with reliable and valid data to support them. (1962, p. 251)

The authors of this paper agree strongly with Stolurow's point of view, although very little of his prophecy has yet come true. Programed instruction is new, and its practitioners and researchers have so far been more concerned with making it work and learning how to use it for practical purposes than in using it as a tool for research on broader questions. But the postponement can be justified. Programed instruction can be a useful research tool in the field of teaching only to the extent that it is developed as a full scale and effective teaching device. Laboratory miniatures must leave many real questions unanswered and more extended investigations incorporating techniques that do not teach will be accepted only reluctantly and temporarily in working schools or even laboratory schools. It is for this reason that this research, aimed at developing Programed Tutoring as a research instrument, has for five years emphasized practical considerations and postponed more scientific questions.

A turning point has now been reached. The concern with improving Programed Tutoring as a teaching device remains, but its present value for this purpose is sufficiently clear that attention can be turned to its use as a technique for investigating other questions related to teaching. For this purpose, as Stolurow and others have suggested, it is well suited. Its most valuable characteristics as a research instrument are two: it provides control and reproducibility of the conditions under which teaching is done; and it provides detailed and sensitive measures of the results. Experiment x gave an indication of the precision of both of these characteristics, the evidence being the close correlation between conditions, defined by the programs, and detailed measures of learning for individual children. In effect, Programed Tutoring is a microscope that can be focused on the teaching process, and its use, which can be justified on more immediate utilitarian grounds, can convert the classroom to an instrumental laboratory.

APPENDIX I

Summary of operational programs

Certain terms with special meanings relevant to Programed Tutoring are defined below:

Unit: a sentence or sequence of sentences to which one cycle of an operational program (Paired Associates, Sight-reading or Comprehension) is applied. In Experiment X units in the Sight-reading Program increased in size from approximately two lines in the first Pre-primer to a page of six to eight lines in the Primer.

Section: a set of eight to twelve units which the learner must read consecutively without error before proceeding to the next one.

Program Section: a division referred to in the text and this appendix which includes several consecutive sections of sight-reading material but only one section of other programs.

Reinforcement: In Experiments I to VII, reinforcement was a brief flash of light. The learner was told that the light indicated he had read a word or other unit correctly. After Experiment VI, reinforcement took the form of verbal approval such as "Good," "That's right," etc.

Required, requires: a term implying that the tutor continues prompting within limits as prescribed by the detailed program until the learner behaves in the specified way, e.g., makes a choice or makes a correct choice.

Paired Associate Program (verbal form)

Materials consist of a deck of ten to sixteen 3×5 cards on each of which is printed one word.

The following procedure is repeated for each word with the deck being shuffled between sections.

Step 1: The tutor shows the word and asks the learner to read it. If he reads it correctly, the tutor reinforces and proceeds to the next word. If he does not read it correctly, the tutor proceeds to Step 2.

Step 2: The tutor shows the word, reads it aloud, and requires the learner to repeat it, then proceeds to Step 3.

Step 3: The tutor removes the word card for approximately one second, then re-presents it and asks the learner to read the word. If the learner reads it correctly, the tutor reinforces and proceeds to the next word, Step 1. If he does not read it correctly, the tutor reads it,

requires the learner to repeat it, and then proceeds to the next word, Step 1.

Sight-reading Program

For the Sight-reading Program an alphabetized list is provided which contains all of the words in the section being tutored.

Step 1: (*Test Step*) The tutor shows the appropriate unit and says, "Can you read this sentence?" If the unit is read correctly orally, the tutor reinforces and proceeds to the next unit, Step 1. If it is not read correctly, the tutor proceeds to Step 2.

Step 2: (*Teaching Step*)–repeated for each word missed in Step 1, in alphabetical order. *a*] The tutor points to the word in the word list and requires the learner to point to that word in the sentence. *b*] The tutor then asks the learner to read the word. If he reads it correctly, the tutor reinforces and proceeds to the next word. If the word is not read correctly, the tutor requires the learner to repeat it, then proceeds to the next word. After the final word, the tutor proceeds to Step 3.

Step 3: (*Test Step*) Same as Step 1 except that failure to read correctly is followed by Step 4.

Step 4: (*Teaching Step*)–repeated for each word missed in Step 3 in alphabetical order. *a*] The tutor reads the word aloud, indicates its approximate location in the word list, and requires the learner to point to it. *b*] Same as Step 2b except that it is followed by Step 5.

Step 5: (*Test Step*) Same as Step 1 except that failure to read correctly is followed by Step 6.

Step 6: (*Teaching Step*)–repeated for each word missed in Step 5 in the order of occurrence in the unit. The tutor points to the word, reads it, and requires the learner to repeat it. After the final word, the tutor proceeds to the next unit, Step 1.

Comprehension programs

All comprehension programs (Instruction, Question, Statement, Story, Completion, and Logical) begin by requiring the learner to read one or more sentences, using the Sight-reading Program when necessary. This is followed by the first step of the Comprehension

Programs. These programs differ in detail but the Statement Comprehension Program summarized below is typical.

Statement comprehension program Materials for each unit of this program consist of a one-sentence statement, a question, and, under a flap, three words, phrases, or sentences, one of which is the correct answer to the question. A picture may be presented with the restriction that it does not provide the answer to the question. Once the Statement and Question are read correctly, the tutor proceeds to Step 1.

Step 1: The learner is required to answer the question correctly. The tutor waits for an answer approximately five seconds after the question is read, and then uses the following prompts as necessary:

1] "Read it again."
2] "Read it faster."
3] "What does it say?"
4] "Tell me the answer."
5] "What is the answer?"
6] "Answer the question."
7] "Look at the sentence again and then tell me the answer."
8] The tutor answers the question, using a complete sentence, and requires the learner to repeat it.

When the learner gives a correct answer, the tutor proceeds to Step 2.

Step 2: The flap is raised and the learner is required to choose the correct answer and then to read it aloud, using the Sight-reading Program if this is necessary.

Word analysis program

The Word Analysis Program was designed to teach grapheme-phoneme correspondences for eight consonants and five vowels in CVC trigrams. The first three sections of the program proper were preceded and followed by letters, words, rhymes, and jingles taught by the Paired Associates and Sight-reading Programs and arranged to provide the children with known or "clue" words. Problems were presented in which parts of the clue words could be selected and reassembled in order to read the unknown or "problem" words. Below is a sample Word Analysis problem.

	1	2	3	4
Clue Words		map	m | om	r | ug
			m | ade	p | ug
		tug	m | ap	t | ug
Problem Word	mug	mug	m | ug	m | ug

In the following procedure, if the learner reads the problem word correctly on any step, the tutor reinforces and proceeds to the next problem.

Step 1: The tutor asks the learner to read the problem word (Column 1). If the problem word is not read correctly, the tutor proceeds to Step 2.

Step 2: The learner sounds out and reads the clue words in Column 2 using the Paired Associates Program if necessary, then proceeds to Step 3.

Step 3: The learner is asked to sound out and read the problem word at the bottom of Column 2. If the word is not read correctly, the tutor proceeds to Step 4.

Step 4: The tutor points to the clue words and then to the problem word in Column 2, saying, "If this is X and this is Y, can you figure out this word?" If the word is not read correctly, the tutor proceeds to Step 5.

Step 5: Pointing to the clue words in Column 3 and then to the problem word, the tutor says, "If these words are X, Y, and Z, can you figure out this word?" If the problem word is not read correctly, the tutor repeats this step using Column 4. If the problem word is still not read, the tutor proceeds to Step 6.

Step 6: The learner is taught to sound out the problem word in Column 4, using the Paired Associates Program, then proceeds to Step 7.

Step 7: The tutor sounds out the problem word and says, "Now, put the parts together and tell me the word." If the problem word is still not read correctly, the tutor says the problem word and an alternative word from which the learner is required to select and repeat the problem word.

APPENDIX II

Sequence of program sections

Section	*Operational Program*	*Content*
1.	Paired Associates	First ten words in Section 2
2.	Sight Reading	*Red Book* (Ginn Pre-Primer #1)
3.	Instruction Comprehension	Based on *Red Book*
4.	Question Comprehension	Based on *Red Book*
5.	Statement Comprehension	Based on *Red Book*
6.	Sight Reading	*Green Book* (Ginn Pre-Primer #2)
7.	Instruction Comprehension	Based on *Green Book*
8.	Question Comprehension	Based on *Green Book*
9.	Statement Comprehension	Based on *Green Book*
10.	Paired Associates	Ten words from Word Analysis Program, Sections 11, 16, 21
11.	Word Analysis, Part 1	p, s, t, i; letter names and 3 initial consonant problems
12.	Sight Reading	*Blue Book* (Ginn Pre-Primer #3)
13.	Instruction Comprehension	Based on *Blue Book*
14.	Question Comprehension	Based on *Blue Book*
15.	Statement Comprehension	Based on *Blue Book*
16.	Word Analysis, Part 2	b, d, m, o; letter names and 3 initial consonant problems
17.	Sight Reading	*The Little White House* (Ginn Primer) pp. 6–30
18.	Story Comprehension	*Little White House*, pp. 6–30
19.	Completion Comprehension	*Little White House*, pp. 6–30
20.	Logical Comprehension	*Little White House*, pp. 6–30
21.	Word Analysis, Part 3	g, n, a, e, u; letter names and 4 initial consonant problems
22.	Sight Reading	*Little White House*, pp. 32–58
23.	Story Comprehension	*Little White House*, pp. 32–58
24.	Completion Comprehension	*Little White House*, pp. 32–58
25.	Logical Comprehension	*Little White House*, pp. 32–58
26.	Paired Associates	16 words from Word Analysis Program, Sections 27, 32, 37, 42, 47, 52
27.	Word Analysis, Part 4	8 initial consonant problems
28.	Sight Reading	*Little White House*, pp. 60–86
29.	Story Comprehension	*Little White House*, pp. 60–86
30.	Completion Comprehension	*Little White House*, pp. 60–86
31.	Logical Comprehension	*Little White House*, pp. 60–86
32.	Word Analysis, Part 5	8 final consonant problems
33.	Sight Reading	*Little White House*, pp. 88–118
34.	Story Comprehension	*Little White House*, pp. 88–118
35.	Completion Comprehension	*Little White House*, pp. 88–118
36.	Logical Comprehension	*Little White House*, pp. 88–118

37.	Word Analysis, Part 6	8 medial vowel problems
38.	Sight Reading	*Little White House,* pp. 120–134
39.	Story Comprehension	*Little White House,* pp. 120–134
40.	Completion Comprehension	*Little White House,* pp. 120–134
41.	Logical Comprehension	*Little White House,* pp. 120–134
42.	Word Analysis, Part 7	8 mixed CVC word analysis problems
43.	Sight Reading	*Little White House,* pp. 136–164
44.	Story Comprehension	*Little White House,* pp. 136–164
45.	Completion Comprehension	*Little White House,* pp. 136–164
46.	Logical Comprehension	*Little White House,* pp. 136–164
47.	Word Analysis, Part 8	8 mixed CVC word analysis problems
48.	Sight Reading	*Little White House,* pp. 165–182
49.	Story Comprehension	*Little White House,* pp. 165–182
50.	Completion Comprehension	*Little White House,* pp. 165–182
51.	Logical Comprehension	*Little White House,* pp. 165–182
52.	Word Analysis, Part 9	8 mixed CVC word analysis problems
53.	Sight Reading	*On Cherry Street,* (Ginn First Reader) pp. 5–14
54.	Sight Reading	*On Cherry Street,* pp. 15–26
55.	Sight Reading	*On Cherry Street,* pp. 27–34

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